Artificial Intelligent Vision Analysis in Obstructive Sleep Apnoea (OSA)

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Introduction

Although polysomnography is a generally adopted approach for diagnosing obstructive sleep apnoea (OSA), there are several critical drawbacks with it, including massive equipment cost, large expense on replacing damaged components and more importantly invasive devices required to be worn while patients are struggling to sleep. Furthermore, there is no proof that polymonography obtains higher accuracy in detecting patients with OSA than more simple investigations [1]. Video monitoring has been adopted to assist diagnosis on obstructive sleep apnoea. From practical researches [3], the best predictors of morbidity in individual patients, as assessed by improvements with CPAP therapy, are nocturnal oxygen saturation [4, 5] and movement during sleep [4]. Hence, we purpose a robotic, objective and reliable video monitoring system with AI intelligence for analysis on human behavior during sleep, automatically generating a statistics report on body activity, including arm movement, limb movement, head movement and body rotation movement and arousal movement.

Method

With corporation with Lincoln County Hospital, we are able to monitor OSA patients. 2 cameras are setup in the sleep lab from different angles. Compression algorithms are built for recording video and audio datum for long sleep period in digital format. For saving 10 hours video and audio data, it takes merely 1.2G space. 2 extra Infrared lights are utilized for better illumination. The distinctive challenge from general body recognition applications is the hidden body covered by the sheet. Hence, sophisticated image processing algorithms are developed for body identification. Also the material of the sheet is soft enough for computer to capture the edge of the body. Fig.1 illustrates the layout of the sleep lab.

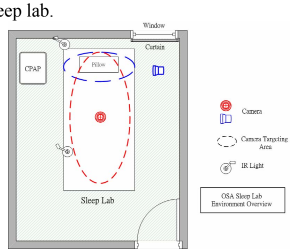
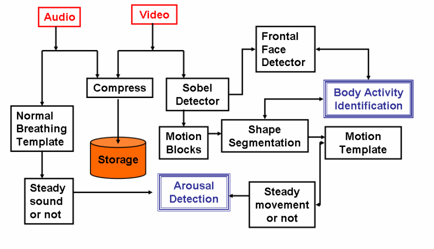


Fig. 1



System Flow & Module Blocks

An optimized Sobel edge detector is built for real time processing, which takes 0.03sec for each 320*240 frame and is able to process in real time (30 frames per second). Fig.2 displays images before and after the processing.

Fig.2

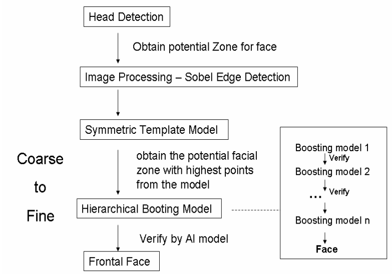


Fig.3

Frontal Facial Detection Model: For individual boosting model, it contains ten base classifiers generated by C4.5 decision tree. The concept of symmetric template model is derived from the symmetric patterns of human face.

Efficient computation approaches are designed for identifying motion blocks and shape segmentation, which are illustrated in Fig.4.

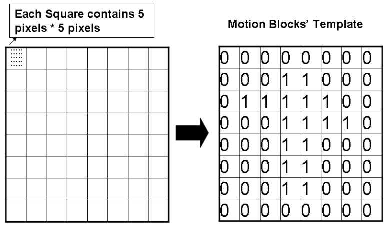


Fig. 4(a). Motion Block Mapping

If summation of the number of motion pixels in individual square is greater than the preset threshold, than mark the block as 1. Otherwise, mark the block as 0.

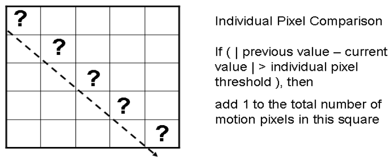


Fig. 4(b). Slant String Fast Comparison

Compare only pixels in the slant string location within each 5 * 5 square unit

A scoring mechanism is purposed, which assigns different weights for each activity and allows the flexibility for users to set up. Total score is summed up for all activity happened for that motion time being.

TABLE I

SCORE MECHANISM IN BODY MOVEMENT

Activity	Weight	Note
Main body rotation	10	
Arm and hand movement	4	
Limb movement	5	
Facial direction	3	
Head movement	2	
Arousal movement	30	
Get up from the bed	0	Total score is set as 100 for notification

Results

The aim for intelligent video analysis of human action is to assist the diagnosis on obstructive sleep apnoea. Consequently, the system should provide a report about the statistics on human activity.

TABLE II

ANALYSIS REPORT IN HUMAN ACTIVITY

Time (hhmmss)	Patient Leave (0➔ true)	Total Score	Events (Body Rotation, Head, Hands, Limbs, Eyelid closure, facial direction)
	0		
021045	1	50	(1,0,0,0,0,0)
021049	1	9	(0,0,1,1,0,0)
..	1	.	…
..	1	.	…
	1		
	0		

Total score for event E = E value (1 or 0) * E's weight

Final Total score = Summation of the total score for events

Conclusions

Sleep quality itself can be estimated from the number of body movements made during sleep, or from electrodes on the head. The addition of an all-night video monitoring is essential, as doubtful areas on the oximetry trace can be reviewed to confirm if any sleep and breathing disorder is present. According to [2], tracings of movement, SaO2, pulse rate and snoring are very characteristic in classic obstructive sleep apnoea, snoring with arousals and snoring alone; if all four tracings are flat then a sleep and breathing disorder is excluded. However, it is a very labor-demanding task to observe the content in long hours, which may generate imprecise diagnosis results because of subjective evaluation standard, tiredness and carelessness. Hence, we purpose a robotic, objective, intelligent and reliable video monitoring system for diagnosis on Obstructive Sleep Apnoea.

References

[1] Douglas, N. J. Sleep Medicine Review 2003
[2] http://www.priory.com/chest.htm
[3] Pepperell JCT et al, Physiological Measurement, 2002
[4] Bennett LS et al, Am J Respir Crit Care Med, 1998
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Acknowledgements

The PhD scholarship of Wang CW is jointly funded by University of Lincoln and United Lincolnshire Hospital NHS TRUST